

Project Handbook

Summary:

MISR, the Multi-angle Imaging SpectroRadiometer, is an instrument unlike any that has flown in space before. Viewing the sunlit Earth simultaneously at nine widely spaced angles, MISR provides ongoing global coverage with high spatial detail. Its imagery is carefully calibrated to provide accurate measures of the brightness, contrast, and color of reflected sunlight.

MISR provides new types of information for scientists studying Earth's climate, such as the regional and global distribution of different types of atmospheric particles and clouds on climate. The change in reflection at different view angles combined with stereoscopic techniques enables construction of 3-D models and estimation of the total amount of sunlight reflected by Earth's diverse environments.

MISR was built for NASA by the Jet Propulsion Laboratory (JPL) in Pasadena, California. It is part of NASA's first Earth Observing System (EOS) spacecraft, the *Terra* spacecraft, which was launched into polar orbit from Vandenberg Air Force Base on December 18, 1999. MISR has been continuously providing data since February 24, 2000.

MISR Observing Concept

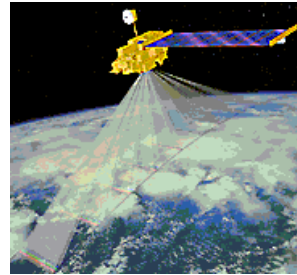


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1. Project Overview:

1.1 Project Mission Objectives:

The MISR instrument acquires systematic multi-angle measurements for global monitoring of top-of-atmosphere and surface albedos and for measuring the shortwave radiative properties of aerosols, clouds, and surface scenes in order to characterize their impact on the Earth's climate. The Earth's climate is constantly changing -- as a consequence of both natural processes and human activities. Scientists care a great deal about even small changes in Earth's climate, since they can affect our comfort and well-being, and possibly our survival. A few years of below-average rainfall, an unusually cold winter, or a change in emissions from a coal-burning power plant, can influence the quality of life of people, plants, and animals in the region involved.

The goal of NASA's Earth Observing System (EOS) is to increase our understanding of the climate changes that are occurring on our planet, and the reasons for these changes, so we are better equipped to anticipate and prepare for the future. The MISR instrument is a part of EOS. Its role is to measure the amount of sunlight scattered in different directions under natural conditions. These measurements will help quantify the amount of solar energy that heats the Earth's surface and atmosphere, and the changes that occur in them over the lifetime of the MISR instrument.

From the MISR observations, we are also learning more about those components of the Earth's environment that scatter sunlight: particles in the atmosphere, the planet's surface, and clouds. MISR monitors changes in surface reflection properties, in atmospheric aerosol content and composition, and in cloudiness. Scientists use these data to study land use changes, air pollution, and volcanic eruptions, as well as processes such as desertification, deforestation, and soil erosion. As part of the EOS program, computer models that predict future climate

Scientific Applications



will be improved by the results of these studies.

Further discussion of the science objectives of the MISR experiment can be found on the [MISR web site's Science Goals and Objectives page](#).

1.2 Geographic Regions

The instantaneous swath of any imaging instrument, including MISR, is the width of the region that is actually observed across the track of the instrument at any time. The instantaneous swaths of the cameras on the MISR instrument vary from about 380 to 410 km, and the instantaneous swaths of the overlap of all cameras is 380 km. This means that whenever MISR passes exactly overhead of a site, its nine cameras also observe the neighborhood of that site up to nearly 200 km on either side of the projection of the track of the Terra platform on the Earth's surface. The swath also refers to the entire region being observed by MISR in the course of one particular orbit: in this case, it refers to an area that is about 20,000 km long and 380 km wide.

The Terra platform that carries MISR and other scientific instruments flies at an altitude of 705 km above sea level on a sun-synchronous orbit. It revolves once around the planet in 98.88 minutes and thus completes about 14.5 revolutions per day. In the context of MISR data exploitation, each complete revolution is called an orbit, and orbits are consecutively numbered from launch. The number of the orbit is thus directly related to the time span since launch.

In practice, since MISR is an optical sensor that measures the reflectance of the Earth in the solar spectral range, it is acquiring useful data only while the Terra platform is over the illuminated (day) side of the planet, i.e., during one half of the complete orbit. Of course, the Earth itself keeps turning around its own axis while Terra proceeds on its orbit. As a result, when Terra completes an orbit and initiates the next one, it actually flies over quite different regions. The orbit number thus also indicates the areas of the planet observed. For these reasons, the orbit number is explicitly included in the name of many MISR data and product files.

The sun-synchronous orbit of Terra was selected in such a way that after 233 revolutions around the planet, or some 16 days, the platform returns to exactly the same locations and observes them under nominally identical angular conditions. Because of the 380 km instantaneous swath width of the MISR instrument, it is possible to gather multiple sets of observations (each with 9 cameras and 4 spectral bands) of a particular site in 2 days (Poles) to 9 days (Equator), depending on its latitude, but of course under a variety of angular conditions. An [Orbit/Date Conversion tool](#) is available from the NASA Langley Research Center Atmospheric Science Data Center (ASDC) web site.

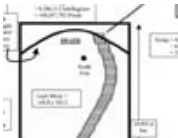
Since the orbits of the Terra platform repeat themselves every 233 revolutions around the Earth, it is natural to name each of these different trajectories or paths. For MISR, the path is the generic name (actually the numeric label) of all orbits that observe the same areas under the same nominal angular conditions. Areas that are close to each other in longitude will be covered by paths with similar numbers. The path number is also included in the file name of MISR products.



**Orbital
Paths/Blocks**

The path numbering system uses the Landsat Worldwide Reference System-2 (WRS-2). WRS-2 consists of 233 paths progressing systematically from east to west, and defined such that path 1 crosses the equator at 64.60° west longitude.

The generic data granule (basic data set) for MISR is a swath, i.e., a set of measurements for the entire area observed during the day part of the orbit. This is a very large amount of data. To simplify the storing and processing of these data, swaths are broken into a series of predefined, uniformly-sized boxes along the ground track called blocks. Each path is divided into 180 blocks measuring 563.2 km (cross-track) x 140.8 km (along-track). For a given path, a numbered block always contains the same geographic locations. Hence, areas that are close to each other in latitude will belong to blocks with similar numbers. Because of seasonal variations in the portion of the Earth that is in daylight, only approximately 142 blocks will contain valid data at any particular time.

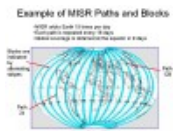


**Schematic
Hierarchy**

A [MISR Browse Tool](#) is available to help determine MISR paths and block numbers for specific geographic regions. There is also an [Orbit/Date Conversion Tool](#) and a [Lat/Lon to MISR Path/Block Tool](#) available.

**Paths/Blocks
Example**

**Browse Tool
Instructions**



The nine MISR cameras acquire measurements on the daylit side of the Earth every 275 m across track (250 m for the An, i.e., nadir, camera). However, the data rate that would be required to transmit all the measurements from the nine cameras in the four spectral bands at that full resolution would exceed the capacity allocated to the MISR instrument on the Terra platform. To retain some of the high spatial resolution of the sensors without exceeding the data transfer quotas, MISR can be operated in two different data acquisition modes.

In global mode (default) a special averaging scheme is conducted on-board such that the data from all cameras other than An and all spectral bands other than red are averaged to 1.1 km before transmission to the receiving station. The spectral data (all 4 bands) from the An camera and the directional data in the red spectral band from all 9 cameras are therefore always available at the full spatial resolution.

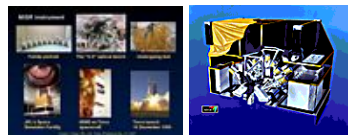
In local mode it is possible to transmit all the data at the full resolution, but only for limited periods of time and therefore for limited regions, typically about 300 km in length (along track). Please refer to the [MISR technical documentation](#) for a detailed description of the various programming modes. Users may contact the ASDC [User and Data Services](#) office to request local mode observations.

1.3 Instrument Description

Illustrations of MISR instrument viewing the Earth:

- [MOV version](#) [13.9 mb]
- [MPEG version](#) [4.1 mb]
- [MISR's nine cameras](#) (MOV version [0.8 mb])

Views of the MISR instrument:



Measuring the reflectance of a target from different directions is useful because geophysical media (the atmosphere, including the clouds and aerosols, the ocean, and terrestrial surfaces such as soil, vegetation and snow or ice) reflect solar light differently in different directions. In fact, the variations between the reflectances acquired from a variety of observation angles can be interpreted (with appropriate models) to document the physical properties of the target, just as the more familiar spectral differences are exploited to document its chemical composition.

Most imaging space-borne instruments acquire measurements for each location on Earth from a single direction at a time, usually within the limited range of (across-track) observation zenith angles allowed by the scanner or push-broom design of the sensor. The accumulation of multiangular observations with such instruments requires multiple visits to a site over rather long periods of time, from multiple days to a few weeks or more. By incorporating nine separate cameras oriented at various angles along the track of the platform, the MISR instrument is capable of acquiring multiple observations of the same site from a wide variety of zenith angles in a matter of a few minutes. This greatly facilitates the interpretation of the measurements and significantly improves the accuracy of the retrieved information. Using its multi-angular and multi-spectral capability, the MISR instrument:

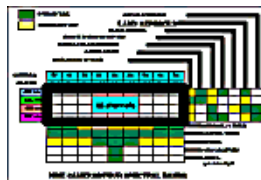
1. better distinguishes between objects and surfaces than would be possible on the basis of spectral variations alone,
2. exhibits an enhanced sensitivity to aerosols and thin cirrus clouds, both of which are ubiquitous and often hard to detect, especially over bright backgrounds,
3. provides a three-dimensional (stereoscopic) view of clouds that allows retrieval of their height, independently of temperature or cloud emissivity assumptions,
4. makes it possible to use clouds as tracers of winds aloft due to the time lapse (about 7 minutes) between the most forward and the most backward views,
5. yields at once measurements that accentuate or minimize the effect of sun glint over the ocean and other water surfaces, thereby enabling observations even when traditional sensors are hampered by the very high reflectance of these surfaces, and
6. permits users to much more accurately estimate the hemispherical albedo of the target, which is calculated on the basis of nine different values instead of only one.

MISR employs nine discrete cameras pointed at fixed angles. MISR's cameras are named Df, Cf, Bf, Af, An, Aa, Ba, Ca, and, Da, beginning with the most forward-viewing oblique camera and ending with the most aft-viewing oblique camera. The initial letter (A, B, C, D) denotes the focal length of the camera lens, with the A cameras having the shortest focal length and the D cameras the longest. With the exception of the A design, which is used for the nadir view as well as the near-nadir views, each letter (B, C, D) also denotes the camera angle, that is, the zenith angle of the optical axis of the camera. The small letters (f, n, a) denote whether the camera is looking forward, nadir, or aftward. Nominally, the view angles for the off-nadir A, B, C, and D cameras are 26.1, 45.6, 60.0, and 70.5 degrees, respectively, relative to a local horizontal plane at mean sea level. There may be small variations with orbital position and location within the field of view. In the product file names, both letters of the camera name are capitalized.



MISR contains 36 parallel signal chains corresponding to the four spectral bands in each of the nine cameras. Each signal chain contains the output from the detectors in each Charge-Coupled Device (CCD) array. The cross-track instantaneous field-of-view (IFOV) and sample spacing of each pixel is 275 m for all of the off-nadir cameras, and 250 m for the nadir camera. Along-track IFOV depends on view angle, ranging from 214 m in the nadir to 707 m at the most oblique angle.

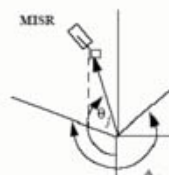
Rationale for Cameras



Bands 1-4 are blue, green, red, and near-infrared, respectively. Variations in spectral response from one camera to another are minor and a standardized, downloadable [spectral response curve](#) in text format for each of the bands is available. Summary spectral response information (e.g., bandcenter, bandwidth) is also available in the Ancillary Radiometric Product ARP_INFLTCAL file, and the mathematical definitions of the product contents are provided in MISR Level 1 In-flight Radiometric Calibration and Characterization [Algorithm Theoretical Basis Document](#) (ATBD-MISR-02). A moments analysis is used to define the "in-band" spectral region. Because the filters are not perfect, there is a small amount of "out-of-band" light (less than 2% of the integrated energy), and the ARP_INFLTCAL file provides spectral response information for both the in-band region of each filter as well as for the total band.

Sun and view angles are available in the MISR Geometric Parameters (MIB2GEOP) data product. Zenith angles are positive values measured from the local vertical at each point. Azimuth angles are measured clockwise from local north to the direction of photon travel. For both the Sun and MISR cameras, azimuth describes the direction in which the photons are traveling. According to this convention the solar azimuth angle is therefore near 270 degrees when Terra is close to the equator, because of its morning equator crossing time. Additionally, the difference in view and solar azimuth angle will be near 0 degrees for forward scattered light, and near 180 degrees for backward scattered light.

Azimuth Angles



Sometimes images within the same path and block cover slightly different regions on the ground. There are three reasons that the ground coverage of two MISR images within the same path and block may differ.

1. The position and pointing of the Terra satellite can vary by a small amount from orbit to orbit. For instance, the position is allowed to vary by no more than 20 km from one overpass to the next. If two images from the same camera for different overpasses are compared, a slight horizontal offset in image location can often be seen. This offset is usually the result of a shift in position of the satellite.
2. The nine MISR camera footprints do not all cover the same exact extent on the ground. This variance occurs because the different camera views are acquired from devices which have different optical designs. In addition, the Earth rotates underneath the satellite in the time that elapses between acquisitions of a particular ground target by two different MISR cameras. Crosstrack boresight offsets are included in the MISR camera pointing angles to compensate, but this does not result in perfect overlap. Therefore, two images from the same orbit but from different cameras almost never display precise overlap in coverage.
3. The MISR cameras are only acquiring imagery over the sunlit portion of the Earth. Therefore a significant seasonal variation of the start block and stop block occurs for orbits within the same path. For example, some blocks acquired in Antarctica in December will not be acquired in June because they are in the dark during the latter month.

MISR data are georectified using the Space Oblique Mercator (SOM) projection. The SOM projection is a space-based map projection in which the reference meridian nominally follows the spacecraft ground track. It provides a mapping from latitude and longitude to a coordinate system that is approximately aligned with the MISR swath. The SOM projection was used because it minimizes distortion and resampling effects, and permits the greatest flexibility in the choice of Earth-based projections. The SOM projection also allows direct cross-comparison with data from other instruments and simplifies global mapping, since the data are already geolocated. For more information see the MISR Level 1 Georectification and Registration [Algorithm Theoretical Basis Document](#) (ATBD-MISR-03), and also Snyder, J.P., *Map Projection - A Working Manual*, United States Geological Survey Professional Paper 1395, U.S. Government Printing Office, Washington, DC (1987).

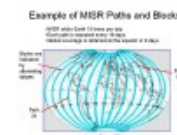
SOM vs Lat/Lon Projection



Orbital Paths/Blocks




Paths/Blocks Example



- Terra orbits Earth in a pattern of 233 unique paths.
- The SOM projection defines a separate projection for each path.
- For MISR, a path begins at a particular longitude as the satellite crosses the ascending node.



Table A: Summary of MISR Instrument

Parameters	Value	Characteristics
Camera view angles at Earth's surface	0.0 degrees (nadir), 26.1, 45.6, 60.0, and 70.5 degrees, both fore and aft of nadir	 <p>Global Mode:</p> <ul style="list-style-type: none"> • 275 m sampling in all nadir bands • 275 m sampling in red band of off-nadir cameras • 1.1 km for other channels <p>Local Mode (targeted):</p> <ul style="list-style-type: none"> • 275 m all channels, all cameras
Swath width	380 km overlap between cameras (9-day global coverage at the equator)	
Cross-track x along-track pixel sampling (selectable)	275 m x 275 m 1.1 km x 1.1 km	
Charge-Coupled Device sensor architecture	4 lines x 1504 active pixels, in each of 9 cameras	
Absolute radiometric uncertainty	3 percent (1 sigma) at maximum signal	
Mass	149 kilograms	
Power	83 watts average, 131 watts peak	
Data rate	3.9 Megabits per second, average	

A more expansive discussion of the instrument and experiment design can be found on the [MISR web site's Instrument Description page](#).

2. Data Products

MISR Level 1 data provide corrected (or calibrated) instrument data. Level 2 data provide retrieval of derived scientific quantities, such as atmospheric aerosol and cloud measurements. Level 3 data produce global maps.

Level 3 globally gridded products, such as aerosol, surface reflectance, cloud and radiance products, became available in July 2002. Level 2 cloud, aerosol, and land surface products became available in February 2001. Level 1 products from MISR data acquired from February 24, 2000 onward are being generated. These include Level 1 raw radiance (Level 1A); radiometrically calibrated imagery (Level 1B1); geolocated, co-registered, map-projected radiance (Level 1B2); browse data; and geometric parameters on a swath-by-swath basis. Additionally, engineering, navigation, and on-board calibrator files are also available, though these are not generally required in order to make use of Level 1 image data. Static data sets required to establish geodetic latitudes and longitudes and surface elevations are also available in the Ancillary Geographic Product. Each of these products is described in this section, and all currently available data products are listed on the ASDC web site in the [MISR Access Data Table](#).

2.1 Level 1 Products

Level 1 data products are processed and calibrated to remove many of the instrument effects. The resulting products thus contain minimal instrument artifacts and are most suitable for subsequent scientific investigations.

2.1.1 Level 1A: Reformatted Annotated Product

The raw data from the instrument, which are intricately structured and compressed, are reformatted into more straightforward computer files. At the same time, many checks are made on the quality of the data to ensure that the instrument is working correctly. By design, L1A does not differ greatly from the raw data except that gaps are filled in with appropriate fill values. There are three categories of products at Level 1A: 1) science data/imagery, 2) engineering data, and 3) calibration/mechanism data.

Only the science data are processed to products higher than Level 1A. The Level 1A data are raw MISR data that are decommutated, reformatted 12-bit Level 0 data shifted to byte boundaries, i.e., reversal of square-root encoding applied and converted to 16 bit, and annotated (e.g., with time information). These data are used by the Level 1B1 processing algorithm to generate calibrated radiances. The science data output preserves the spatial sampling rate of the Level 0 raw MISR CCD science data. CCD data are collected during routine science observations of the sunlit portion of the Earth. Each product represents one "granule" of data. A "granule" is defined to be the smallest unit of data required for MISR processing. Also, included in the Level 1A product are pointers to calibration coefficient files provided for Level 1B processing.

The engineering data and the calibration/mechanism data are not used as input to any of the other MISR products. They are normally used only at the MISR SCF for instrument monitoring and characterization, and they are not described in this document.



Data Product (ESDT):	MIL1A
Data Set Long Name:	MISR Level 1A camera charge-coupled device (CCD) Science Data
Sample File Name:	MISR_AM1_FM_SCI_Pxxx_Oxxxxxx_XX_Fnn_nnnn.hdf where MISR = Instrument Name AM1 = Satellite Name SCI = Science Pxxx = Path Number Oxxxxxx = Orbit Number XX = Camera Fnn = Format (software) version of the product nnnn = Product Version number
Parameters:	Sensor Counts and Visible Imagery
Data Format:	HDF-EOS

2.1.2 Level 1B1: Radiometric Product

The results of two types of processing are included in this product. First, the Radiance Scaling operation converts the camera's digital number output to a measure of energy incident on the front optical surface. The measurement is expressed in units called radiance (energy per unit area, wavelength, and solid angle) as defined by the International Standard (SI). Second, Radiance Conditioning modifies the radiances to remove instrument-dependent effects. Specifically, image sharpening is applied, and focal-plane scattering is removed. Additionally, all radiances are adjusted to remove slight spectral sensitivity differences among the 1504 detector elements of each spectral band and each camera. In addition to the Level 1B1 radiometric product for MISR's Global Mode imagery, there is a separate Level 1B1 product for each high-resolution Local Mode scene.

The Radiometric Product contains spectral radiances for all MISR channels (four spectral bands and nine cameras). Each radiance value represents the incident radiance averaged over the sensor's total band response. Processing includes both radiance scaling and conditioning steps. Radiance scaling converts the Level 1A data from digital counts to radiances using coefficients derived in combination with the On-Board Calibrator (OBC) and vicarious calibrations. The OBC contains Spectralon calibration panels which are deployed monthly and reflect sunlight into the cameras. The OBC detector standards then measure this reflected light to provide the calibration. Vicarious field campaigns are conducted less frequently but provide an independent methodology useful for reducing systematic errors.

Radiance conditioning removes undesirable instrument effects. Image enhancement is provided by deconvolving the scene with the sensor's point-spread-function. Additionally, in-band scaling adjusts the reported radiances to correspond to a nominal band response profile. This frees the Level 2 software from the need to correct for detector element non-uniformities. No out-of-band correction is done for this product, nor are the data geometrically corrected or resampled at this point. In summary, the Level 1B1 Product contains the Data Numbers (DNs) radiometrically-scaled to radiances with no geometric resampling.

Data Product (ESDT):	MI1B1 MI1BLM
Data Set Long Name:	MISR Level 1B1 Radiance Data MISR Level 1B1 Local Mode Radiance Data
Sample File Name:	MISR_AM1_RP_GM_Pxxx_Oxxxxxx_XX_Fnn_nnnn.hdf MISR_AM1_RP_LM_Pxxx_Oxxxxxx_XX_SITE_[sitename]_Fnn_nnnn.hdf where MISR = Instrument Name AM1 = Satellite Name RP_GM = Radiance Product Global Mode RP_LM = Radiance Product Local Mode Pxxx = Path Number Oxxxxxx = Orbit Number XX = Camera Fnn = Format (software) version of the product nnnn = Product Version number
Parameters:	Visible Imagery
Data Format:	HDF-EOS Swath

2.1.3 Level 1B2: Georectified Radiance Product

The nine sets of imagery from the nine cameras are registered to one another and to the ground. This is an image processing application made necessary because the nine views of each point on the ground are not acquired simultaneously (images from cameras at the two extreme angles are 7 minutes apart.) This product is mapped into a standard Space Oblique Mercator (SOM) map projection. There is a cloud mask derived as part of the Level 1B2, called the Radiometric

Example MISR L1B2 Georectified Radiance Product



Camera-by-camera Cloud Mask (RCCM). Other types of cloud mask form part of the Level 2 products.



The Georectified Radiance Product (GRP) consists of parameters that are geometrically corrected and are projected to an SOM map grid. Included in this product is the surface-projected Top of Atmosphere (TOA) radiance which is the calibrated radiance from the Level 1B1 data that has had a geometric correction applied to remove spacecraft position and pointing knowledge errors as well as effects due to topography. The radiance is then orthorectified on a reference ellipsoid at the surface. Also, part of the GRP is the ellipsoid-projected TOA radiance which uses supplied spacecraft position and pointing and is not corrected for topography, but is resampled at the surface reference ellipsoid. In addition, geometric parameters such as solar and view zenith and azimuth angles are included.

Resampling of MISR data at Level 1B2 is critical because the pushbroom images from the nine cameras are obtained at widely separated locations along the sub-spacecraft track. However, derivation of geophysical products requires that the multi-angle, multi-spectral radiances for any single ground target be coregistered.

Most of the time that MISR is acquiring Earth imagery it operates in a configuration called Global Mode, which allows the spatial resolution to be set for each individual channel (there are 36 channels on MISR: 4 bands at each of 9 angles). Currently Global Mode is defined to provide 275 m resolution data in all bands of the An (nadir) camera and in the red band of all the off-nadir cameras. The highest resolution available is 275 m, and is called 1x1 data since it involves no on-board pixel averaging. In the remaining channels 4 samples x 4 lines are averaged within the instrument to create a 4x4, or 1.1-km resolution sample. In the L1B2 product, 1x1 data map to a 2048x512 array, whereas 4x4 data map to a 512x128 array. Thus, samples 1-4 in lines 1-4, for example, in 2048x512 data correspond on the SOM grid to the same location as sample 1, line 1, in a 512x128 array.

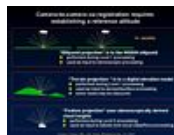
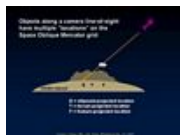
There is a L1B2 Ellipsoid data product and a L1B2 Terrain data product. Note that there is a difference between the L1B2 Ellipsoid and Terrain georectified radiances. In order to resample the data from the nine MISR cameras to the SOM grid, it is necessary to assign an altitude to each location on the grid.

The Ellipsoid product is referenced to the World Geodetic System 1984 (WGS84) ellipsoid, which approximates the Earth's shape at sea level. In this product, the radiances and associated altitudes are projected to the ellipsoid, so that higher elevation data appear displaced from their true location for non-nadir camera views, much as they are seen by the instrument. (A cloud at location F, or a mountain top at location T in the image below appears as if it is at location E.) The more oblique the camera view, or the higher in altitude the feature, the more displaced the elevated data will appear. This displacement is used to advantage in MISR stereo retrievals, and this product is the primary input to Level 2 top-of-atmosphere/cloud processing.

In the Terrain product, the data are re-projected to the terrain altitude. In this product, surface data from all cameras will appear in the same geographic location. Thus, this product is the primary input to Level 2 aerosol/surface processing, which requires co-registration of the L1B2 imagery at the surface. Clouds will still be displaced due to their elevation above the surface, but this time with respect to the terrain rather than the ellipsoid. (The mountain location T is now assigned the geographic location at T, and the Cloud at F appears at the geographic location T.) In Level 2 aerosol/surface processing, algorithms are applied to screen out the clouds. Terrain data only exist for MISR blocks containing some land.

Both products are divided into 180 blocks measuring 563.2 km (cross-track) x 140.8 km (along-track).

Illustration of Ellipsoid vs Terrain Projection

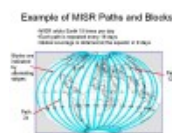


The L1B2 product contains a hierarchy of metadata fields to assist in determining which data are relevant. All L1B2 files begin with block number 1, even though the sunlit portion of the orbit rarely begins in the first block. Refer to the file metadata attributes "Start_block" and "End_block" in order to locate valid data. **Note:** The missing underscore in "End_block" is real. The L1B2 per-block metadata also contains a data valid flag which is normally set to 1 for blocks within the Start_block and End_block range. In rare cases, the L1B2 software is forced to skip an entire block in order to complete. In these cases, the data valid flag for that block is set to 0.

Illustration of Blocks



Paths/Blocks Example



Any target in the MISR imagery which is not at the altitude at which the L1B2 product is registered will show parallax from one angle to another. This parallax is a function of the target's height relative to the projection altitude. For example, to visualize both topographic relief and cloud altitudes stereoscopically, the Ellipsoid-projected product is the appropriate product. Applications which require the data to be co-registered at the land surface altitude should use the Terrain-projected product.

Fill values are used to indicate pixels with unavailable data in the L1B2 data products. In both the Ellipsoid and Terrain products, a fill value of 16378 is used when a location is not seen by the camera, either on the cross-track edges of a block or in the non-sunlit portion at the beginning and/or end of the orbit. When the Radiometric Data Quality Indicator shows a pixel is unusable, a fill value of 16380 is written.

To avoid redundancy and reduce file sizes, when a Terrain product block contains no land its pixels are assigned the fill value of 6379. Ocean radiance values for these blocks can be obtained from the Ellipsoid product, where they are correctly registered at the surface.

A user may sometimes see bright speckles in an image from the Terrain product, particularly at oblique camera angles. MISR Level 1B2 data products use various high data values to signify fill, and one of the fill values (16377) in the 14 MSB's (Most Significant Bits) of the scaled radiances signifies that this location on the SOM grid was obscured from the camera's view by intervening topography. Because greater amounts of topographic obscuration occur at the more oblique angles, the prevalence of this particular fill value increases as the view angle increases. This particular fill value does not apply to the Ellipsoid product, because for each sample, whatever radiance was observed along the line of sight is projected to the ellipsoid grid location.

The RCCM is derived from the radiance values, and is calculated independently for each camera. Therefore, the amount of apparent cloudiness will vary with view angle, with the oblique view angles generally being more cloudy than the near-nadir ones. Since the RCCM is calculated primarily from the radiance values, it does not work well over snow and ice and will usually confuse clear snow/ice with cloud. It works the best over clear-sky ocean, but other surface types are also of quite good quality.

The RCCM product also contains a glint mask for each camera, and this mask is set to true whenever the scattering angles indicate that glint could be possible. This glint mask is not masked out over land; users must do this step themselves.

Data Products (ESDT):

Data Set Long Names:

Sample File Names:

MI1B2E | MI1B2T | MIB2GEOP | MIRCCM

MISR Level 1B2 Ellipsoid Data | MISR Level 1B2 Terrain Data |
MISR Geometric Parameters | MISR Level 1B2 Radiometric
Camera-by-Camera Cloud Mask

MISR_AM1_GRP_ELLIPSOID_GM_Pxxx_Oxxxxxx_XX_Fnn_n
nnn.hdf
MISR_AM1_GRP_TERRAIN_GM_Pxxx_Oxxxxxx_XX_Fnn_nn
nn.hdf
MISR_AM1_GP_GMP_Pxxx_Oxxxxxx_XX_Fnn_nnnn.hdf
MISR_AM1_GRP_RCCM_GM_Pxxx_Oxxxxxx_XX_Fnn_nnnn
.hdf

where
MISR = Instrument Name
AM1 = Satellite Name
GRP = Georectified Radiance Product
GP = Geometric Parameters
GMP =
RCCM = Radiometric Camera-by-camera Cloud Mask
GM = Global Mode
Pxxx = Path Number
Oxxxxxx = Orbit Number
XX = Camera
Fnn = Format (software) version of the product
nnnn = Product Version number

Parameters:

Data Format:

Radiance, Images, Sun and View Angles, and Radiometric
Cloud Mask

MI1B2T and MI1B2E are HDF-EOS Swath

MIB2GEOP and MIRCCM are HDF-EOS Grid

2.1.4 MISR Browse Product

A [MISR Browse Tool](#) is available to allow easy access to ellipsoid-derived, true-color images for each camera reduced to 2.2 km resolution. The MISR red, green and blue bands are used to create the true-color image in JPEG format. The image is intentionally clipped and gamma-stretched to make cloud, ocean and land features visible. The user may find the Browse Tool helpful before ordering data. The tool's purpose is to search and view images in the on-line user interface. However, the browse product can be ordered separately. The Browse Tool page has Orbit-to-Date and Lat/Lon-to-Path/Block conversion tools to help identify particular MISR geographic locations and data files.



Data Products (ESDT):
 Data Set Long Names:
 Sample File Names:

MISBR
 MISR Browse Data
 MISR_AM1_GRP_ELLIPSOID_BR_GM_Pxxx_Oxxxxxx_XX_Fnn_nnnn.hdf
 where
 MISR = Instrument Name
 AM1 = Satellite Name
 GRP = Georectified Radiance Product
 BR = Browse
 GM = Global Mode
 Pxxx = Path Number
 Oxxxxxx = Orbit Number
 XX = Camera
 Fnn = Format (software) version of the product
 nnnn = Product Version number

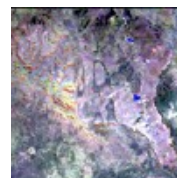
Parameters:
 Data Format:

Images
 JPEG

2.1.5 Local Mode Product

In addition to the Level 1B2 Global Mode imagery, MISR can be configured to disable the on-board data averaging and provide high resolution images in all 36 channels for selected targets and observation times. This capability is referred to as Local Mode (LM). The result is a scene with a crosstrack pixel spacing of 275 m, with downtrack sampling also at 275 m, over a spatial area of approximately 300 km downtrack by 360 km crosstrack.

Example MISR Local Mode Product



Data Products (ESDT):
 Data Set Long Name:
 Sample File Names:

MIB2LMT | MIB2LME
 MISR Level 1B2 Local Mode Terrain Radiance Data | MISR Level 1B2 Local Mode Ellipsoid Data
 MISR_AM1_GRP_TERRAIN_LM_Pxxx_Oxxxxxx_XX_SITE_[sitename]_Fnn_nnnn.hdf
 MISR_AM1_GRP_ELLIPSOID_LM_Pxxx_Oxxxxxx_XX_SITE_[sitename]_Fnn_nnnn.hdf
 where
 MISR = Instrument Name
 AM1 = Satellite Name
 GRP = Georectified Radiance Product
 LM = Local Mode
 Pxxx = Path Number
 Oxxxxxx = Orbit Number
 XX = Camera
 SITE_[sitename] = selected targets
 Fnn = Format (software) version of the product
 nnnn = Product Version number

Parameters:
 Data Format:

Radiance
 HDF-EOS Grid

2.2 Level 2 Products

The MISR Level 2 Products are geophysical parameters retrieved from the Level 1B2 data. The Level 2 products are in swaths, each derived from a single MISR orbit, where the parameters cover an area 360 km wide by approximately 20,000 km long. The swaths are divided into 180 blocks measuring 563.2 km (cross-track) x 140.8 km (along-track).

2.2.1 Level 2TC: Top-of-Atmosphere/Cloud Product

The MISR Top-of-Atmosphere (TOA)/Cloud Products include Stereo,

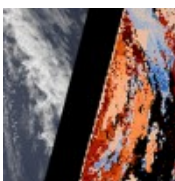
Example MISR L2 TOA/Cloud Product



Distributed by the Atmospheric Science Data Center
<http://eosweb.larc.nasa.gov>



Classifiers, and Albedo product files. The MISR Top-of-Atmosphere (TOA)/Cloud Stereo geophysical parameters include stereoscopically-derived cloud motion vectors (winds), cloud-top heights, and an accompanying cloud mask. The cloud motion parameters are calculated on a 70.4km grid, and the cloud-heights are available at 1.1km resolution.



The Stereo product geophysical parameters include a stereoscopically-derived cloud mask and cloud height on a 1.1 km grid. It also includes cloud motion vectors on a 70.4 km grid. The stereo heights come in three flavors: the BestWind heights are only calculated for those regions where the associated wind vectors passed the quality tests. Therefore, they have sparse coverage but since the wind correction is included, these contain our "best guess" as to what the true heights are. The WithoutWind heights are calculated assuming a constant wind vector of zero. They have almost complete coverage and therefore form a nice "pretty picture" of the relative cloud heights over small areas. The RawWind heights are a diagnostic product as they are calculated using all available wind vectors (even the bad ones). It is therefore recommended that one only use the Best and Without wind products. It is important to remember that the stereo matchers pick up the layer of maximum contrast, which is not necessarily the same as the highest cloud so all the stereo heights are keyed to this level of maximum contrast. Therefore, higher and thinner cirrus layers may not be detected by any of the height fields.

The TOA/Cloud Classifiers contain the Angular Signature Cloud Mask (ASCM), a scene classifier calculated using support vector machine technology (SVM) both of which are on a 1.1 km grid, and cloud fractions at 17.6 km resolution that are available in different height bins (low, middle, high) and are also calculated on an angle-by-angle basis.

The TOA/Cloud Albedo data contain albedo values, including finely-sampled or local (2.2 km) TOA albedos registered to the RLRA, and two coarsely-sampled (35.2 km resolution) TOA albedos projected to 30-km altitude. The local (2.2 km) albedos do not take the obscuration of cloud features into account, so they should only be treated as traditional albedos when the number of obscured pixels is low. The restrictive and expansive albedos are both available at 35.2 km resolution: the restrictive albedos are only calculated using the radiation upwelling from the pixel under consideration, whereas the expansive albedos use all the radiation emanating from the surrounding area. Therefore, the expansive albedo is closer to the traditional definition of top-of-atmosphere albedos.

Data Products (ESDT):

Data Set Long Name:

Sample File Name:

MIL2TCST | MIL2TCAL | MIL2TCCL

MISR Level 2 Top of Atmosphere/Cloud Stereo parameters

MISR Level 2 Top of Atmosphere/Cloud Albedo parameters

MISR Level 2 Top of Atmosphere/Cloud Classifier parameters

MISR_AM1_TC_STEREO_Pxxx_Oxxxxxx_Fnn_nnnn.hdf

MISR_AM1_TC_ALBEDO_Pxxx_Oxxxxxx_Fnn_nnnn.hdf

MISR_AM1_TC_CLASSIFIERS_Pxxx_Oxxxxxx_Fnn_nnnn.hdf

where

MISR = Instrument Name

AM1 = Satellite Name

TC = Top-of-Atmosphere/Cloud Product

Pxxx = Path Number

Oxxxxxx = Orbit Number

XX = Camera

Fnn = Format (software) version of the product

nnnn = Product Version number

Parameters:

Data Format:

Cloud Amount/Frequency, Cloud Heights, Albedo, Anisotropy, Cloud Forcing, Cloud Types, Radiative Forcing, Reflectance

HDF-EOS Stacked block Grid



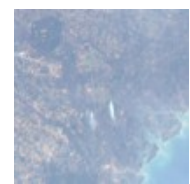
Distributed by the Atmospheric Science Data Center
<http://eosweb.larc.nasa.gov>



2.2.2 Level 2AS: Aerosol/Surface/Ocean Product

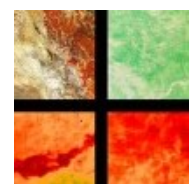
The Aerosol data (MIL2ASAE) contain aerosol optical depth, aerosol physical model, ancillary meteorological data, and related parameters. The aerosol data include tropospheric aerosol optical depth, Angstrom exponent and single scattering albedo on 17.6 km centers, aerosol mixture identifier and retrieval residuals, and ancillary data including assumed ozone optical depth and retrieval flags. For complete information about the aerosol mixtures, the user will need to order the MISR Aerosol Climatology Product (MIANACP) to obtain Aerosol Physical and Optical Properties (APOP) and the Mixture files. The Mixture files list up to 3 component models used in each mixture, with their relative compositional fractions, and includes ancillary information such as single scattering albedo. The APOP gives detailed information for the component particle models. The [Algorithm Theoretical Basis Document \(ATBD\)](#) contains more information on MISR aerosol retrieval.

Example MISR L2 Aerosol Product



The Land Surface data (MIL2ASLS) include bihemispherical and directional-hemispherical reflectances (albedo), hemispherical directional and bidirectional reflectance factors (BRF), BRF model parameters, leaf-area index (LAI), fraction of photosynthetically active radiation (FPAR), and normalized difference vegetation index (NDVI) on a 1.1 km grid. The land surface data include hemispherical directional reflectance factor, bihemispherical reflectance (i.e., albedo), bidirectional reflectance factor, directional hemispherical reflectance, BRF model parameters, FPAR, and terrain-referenced view and illumination angles.

Example MISR L2 Surface Product



Data Products (ESDT):
Data Set Long Name:

Sample File Name:

MIL2ASAE | MIL2ASLS | MIL2ASOS
MISR Level 2 Aerosol parameters
MISR Level 2 Land Surface parameters
MISR Level 2 Ocean Surface parameters (unavailable)
MISR_AM1_AS_AEROSOL_Pxxx_Oxxxxxx_Fnn_nnnn.hdf
MISR_AM1_AS_LAND_Pxxx_Oxxxxxx_Fnn_nnnn.hdf
Ocean data currently unavailable
where
MISR = Instrument Name
AM1 = Satellite Name
AS = Aerosol
Pxxx = Path Number
Oxxxxxx = Orbit Number
XX = Camera
Fnn = Format (software) version of the product
nnnn = Product Version number

Parameters:

Aerosol Optical Depth, Aerosol Particle Properties, Particulates, Turbidity, Land Cover, Canopy Characteristics, Land Use Classes, Plant Characteristics, Reflectance, Vegetation Cover
HDF-EOS Stacked block Grid

Data Format:

2.3 Level 3 Products

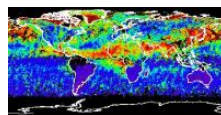
The Level 3 products are globally gridded statistical summaries (daily, monthly, quarterly, and yearly) of a range of parameters from select Level 1 and Level 2 products. The Level 1 and 2 products are in swaths, each derived from a single MISR orbit, where the measurements are 360 km wide and approximately 20,000 km long. At Level 3 the product parameters from multiple swaths are combined to make complete, global maps. Note that the quarterly data are seasonal, and the seasons are named for the season in the northern hemisphere:

Table C: MISR Seasons

Season	Months
Winter	December (previous year), January, February
Spring	March, April, May
Summer	June, July, August
Fall	September, October, November



The [MISR Level 3 Imagery](#) provides easy access to images of select parameters within these products. The images are in JPEG format and show parameters averaged over monthly, seasonal, or annual time periods. Images can be viewed as a traditional flat map, or as a three-dimensional globe. Images can be animated through each month or season of a year. Advanced options allow animation through all years. Radiances can also be animated through the nine MISR cameras.



Level 3 Imagery

2.3.1 Component Global Albedo Product (CGAL)

The CGAL product contains local, restrictive, and expansive albedo reported on $1^\circ \times 1^\circ$ and $.5^\circ \times .5^\circ$ grids, together with their zonal average values.

Data Products (ESDT):

Data Set Long Name:

Sample File Name:

MIL3DAL | MIL3MAL | MIL3QAL | MIL3YAL

MISR Level Component Global Albedo Product Covering a Day

MISR Level Component Global Albedo Product Covering a Month

MISR Level Component Global Albedo Product Covering a Quarter (Seasonal)

MISR Level Component Global Albedo Product Covering a Year

MISR_AM1_CGAL_MMM_DD_YYYY_Fnn_nnnn.hdf

MISR_AM1_CGAL_MMM_YYYY_Fnn_nnnn.hdf

MISR_AM1_CGAL_SSS_YYYY_Fnn_nnnn.hdf

MISR_AM1_CGAL_YYYY_Fnn_nnnn.hdf

where

MISR = Instrument Name

AM1 = Satellite Name

[text] = Product File Name Prefix

MMM = Month Prefix

DD = Day

SSS = Quarter (Season)

YYYY = Year

Fnn = Format (software) version of the product

nnnn = Product Version number

Data Format:

HDF-EOS Grid

2.3.2 Component Global Land Surface Product (CGLS)

The CGLS product contains statistical summaries of Directional Hemispheric Reflectance (DHR), DHR Photosynthetically Active Radiation (PAR), Fractional absorbed PAR (FPAR), Leaf Area Index (LAI), DHR-based Normalized Difference Vegetation Index (NDVI).

Data Products (ESDT):

Data Set Long Name:

Sample File Name:

MIL3DLS | MIL3MLS | MIL3QLS | MIL3YLS

MISR Level Component Global Land Surface Product Covering a Day

MISR Level Component Global Land Surface Product Covering a Month

MISR Level Component Global Land Surface Product Covering a Quarter (Seasonal)

MISR Level Component Global Land Surface Product Covering a Year

MISR_AM1_CGLS_MMM_DD_YYYY_Fnn_nnnn.hdf

MISR_AM1_CGLS_MMM_YYYY_Fnn_nnnn.hdf

MISR_AM1_CGLS_SSS_YYYY_Fnn_nnnn.hdf

MISR_AM1_CGLS_YYYY_Fnn_nnnn.hdf

where

MISR = Instrument Name

AM1 = Satellite Name

[text] = Product File Name Prefix

MMM = Month Prefix

DD = Day

SSS = Quarter (Season)

YYYY = Year



Fnn = Format (software) version of the product
nnnn = Product Version number

Data Format:

HDF-EOS Grid

2.3.3 Component Global Georectified Radiance Product (CGGRP)

The CGGRP product contains radiances for each camera and band with associated covariances.

Data Products (ESDT):
Data Set Long Name:

MIL3DRD | MIL3MRD | MIL3QRD | MIL3YRD
MISR Level Component Global Radiance Product Covering a Day
MISR Level Component Global Radiance Product Covering a Month
MISR Level Component Global Radiance Product Covering a Quarter (Seasonal)
MISR Level Component Global Radiance Product Covering a Year
MISR_AM1_CGGRP_MMM_DD_YYYY_Fnn_nnnn.hdf
MISR_AM1_CGGRP_MMM_YYYY_Fnn_nnnn.hdf
MISR_AM1_CGGRP_SSS_YYYY_Fnn_nnnn.hdf
MISR_AM1_CGGRP_YYYY_Fnn_nnnn.hdf

Sample File Name:

where
MISR = Instrument Name
AM1 = Satellite Name
[text] = Product File Name Prefix
MMM = Month Prefix
DD = Day
SSS = Quarter (Season)
YYYY = Year
Fnn = Format (software) version of the product
nnnn = Product Version number

Data Format:

HDF-EOS Grid

2.3.4 Component Global Aerosol Product (CGAS)

The CGAS product contains average aerosol optical depth.

The CGAS contains a statistical summary of column aerosol 555-nm optical depth, and a monthly aerosol compositional type frequency histogram.

Data Products (ESDT):
Data Set Long Name:

MIL3DAE | MIL3MAE | MIL3QAE | MIL3YAE
MISR Level Component Global Aerosol Product Covering a Day
MISR Level Component Global Aerosol Product Covering a Month
MISR Level Component Global Aerosol Product Covering a Quarter (Seasonal)
MISR Level Component Global Aerosol Product Covering a Year
MISR_AM1_CGAS_MMM_DD_YYYY_Fnn_nnnn.hdf
MISR_AM1_CGAS_MMM_YYYY_Fnn_nnnn.hdf
MISR_AM1_CGAS_SSS_YYYY_Fnn_nnnn.hdf
MISR_AM1_CGAS_YYYY_Fnn_nnnn.hdf

Sample File Name:

where
MISR = Instrument Name
AM1 = Satellite Name
[text] = Product File Name Prefix
MMM = Month Prefix
DD = Day
SSS = Quarter (Season)
YYYY = Year
Fnn = Format (software) version of the product
nnnn = Product Version number

Data Format:

HDF-EOS Grid

2.3.5 Component Global Cloud Product (CGCL)

The CGCL product contains a statistical summary of cloud stereo heights and cloud-derived wind speed.

Data Products (ESDT):

MIL3DCLD | MIL3MCLD | MIL3QCLD | MIL3YCLD



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<http://eosweb.larc.nasa.gov>



Data Set Long Name:	MISR Level Component Global Cloud Product Covering a Day MISR Level Component Global Cloud Product Covering a Month MISR Level Component Global Cloud Product Covering a Quarter (Seasonal) MISR Level Component Global Cloud Product Covering a Year
Sample File Name:	MISR_AM1_CGCL_MMM_DD_YYYY_Fnn_nnnn.hdf MISR_AM1_CGCL_MMM_YYYY_Fnn_nnnn.hdf MISR_AM1_CGCL_SSS_YYYY_Fnn_nnnn.hdf MISR_AM1_CGCL_YYYY_Fnn_nnnn.hdf where MISR = Instrument Name AM1 = Satellite Name [text] = Product File Name Prefix MMM = Month Prefix DD = Day SSS = Quarter (Season) YYYY = Year Fnn = Format (software) version of the product nnnn = Product Version number
Data Format:	HDF-EOS Grid

2.4 Ancillary products

In addition to the product files, most users need to be cognizant of certain ancillary files associated with MISR data product generation. In some instances, the ancillary file is essential to a complete understanding and utilization of the data product. There are other ancillary files not relevant to utilization of the products. These ancillary files are referred to as the Ancillary Data Products. Here is a more complete definition of the terminology.

- **Standard product:** Product generated routinely at ASDC and is what is usually understood when talking about data products.
- **Ancillary data set:** Data set generated at the MISR SCF and delivered to ASDC for use as input during routine processing. Ancillary data sets may be updated either on a regular or sporadic basis at the SCF and new versions delivered to ASDC. In some cases, automated updating may occur at ASDC. Ancillary data sets are not required by users of MISR data to interpret the contents of standard products, and are not designed for end-user usage. These data sets are not designed for distribution but may be available on request, with the exception of a few that are restricted because of their origin within the non-NASA community.
- **Ancillary product:** Product generated at the SCF and delivered to ASDC for use during routine processing or as a supportive product necessary for the interpretation of standard products. Ancillary products may be updated either on a regular or sporadic basis at the SCF and new versions delivered to ASDC. Ancillary products are distinguished from ancillary data sets in that they are needed by users of MISR data to interpret the contents of standard products.
- **Parameter:** Variable contained within a product or data set.

2.4.1 MISR Aerosol Climatology Product (MIANACP)

The ACP contains the microphysical and scattering characteristics of component aerosol particle models upon which routine retrievals are based, radiances computed from mixtures of component models to be compared with MISR observations.

The MISR aerosol retrieval algorithm relies on comparing observed radiances with those calculated from a forward radiative transfer code, input with an assumed aerosol climatology and a range of column optical depths. The ACP *describes mixtures of up to three component aerosol types from a list of components*, in varying proportions, which are used by the retrieval algorithm. ACP component aerosol particle data quality depends on the ACP input data, which are based on aerosol particles described in the literature, and take into account MISR-specific sensitivity to particle size, single-scattering albedo, and shape -- *roughly: small, medium and large; dirty and clean; spherical and nonspherical* [Kahn et al., 1998; 2001]. Components are expected to be refined further as a result of validation studies currently underway.

The ACP provides detailed information for understanding the aerosol data. The ACP contains the physical and optical properties that define common atmospheric aerosol types. The parameters reported in the ACP include an aerosol model identifier (name, number, and composition); a water activity identifier (hygroscopic or not, and if so, how hydrophilic); a partial shape identifier (spherical, polyhedral, or irregular); a grid of relative humidity values for which all optical properties have been calculated; particle size distribution parameters; particle density (volume-weighted for mixtures); complex index of refraction; scattering and extinction cross-section; single scattering albedo; scattering anisotropy parameter; and phase function. It also includes the definition of the aerosol mixtures.

MISR plans to add an update to the Clim-Likely dataset (section 2.5.1) based on MISR aerosol retrieval results, which will become part of the Aerosol Climatology Product. This dataset will represent the global climatological likelihood parameters for the MISR-defined aerosol mixtures.

Data Product (ESDT):	MIANACP
Data Set Long Name:	MISR Aerosol Climatology Product
Sample File Name:	MISR_AM1_ACP_APOP_Fnn_nnnn.hdf



Distributed by the Atmospheric Science Data Center
<http://eosweb.larc.nasa.gov>



where
 MISR = Instrument Name
 AM1 = Satellite Name
 ACP = Aerosol Climatology Product
 APOP = Aerosol Physical and Optical Pillary Radiometric Product
 Fnn = Format (software) version of the product
 nnnn = Product Version number

Data Format: Binary

2.4.2 MISR Ancillary Geographic Product (MIANCAGP)

The AGP contains geolocation data on a Space Oblique Mercator (SOM) grid. It has 233 files, where each file pertains to a single Terra orbital path. MISR production software relies on information in the AGP, such as digital terrain elevation, as input to the algorithms which generate MISR products.

AGP contents include latitude, longitude, scene elevation (average and standard deviation), topographic shadow and obscuration mask, surface-normal zenith angle, and a land/ocean/inland water/ephemeral water/coastline mask. The AGP is used as input to Level 1B2 and Level 2 processing. It is an archival product generated once preflight at the MISR SCF, but is available to the scientific community as an aid in interpreting MISR retrievals. All parameters are given on 1.1 km centers.

The values of the latitude and longitude of an L1B2 SOM grid location are stored on the "Standard" grid of the AGP. Latitudes are geodetic, and longitudes are relative to the Greenwich meridian, positive to the east and negative to the west. The fields "GeoLatitude" and "GeoLongitude" contain this information.

The surface altitude is obtained from a high-resolution Digital Elevation Model (DEM), referenced to the WGS-84 referenced ellipsoid and mapped onto an SOM grid. The field "AveSceneElev" contains this information.

Data Product (ESDT): MIANCAGP
 Data Set Long Name: MISR Ancillary Geographic Product
 Sample File Name: MISR_AM1_AGP_Pxxx_Fnn_nn.hdf

where
 MISR = Instrument Name
 AM1 = Satellite Name
 AGP = Ancillary Geographic Product
 Pxxx = Path Number
 Fnn = Format (software) version of the product
 nn = Product Version number

Data Format: HDF-EOS Grid

2.4.3 MISR Ancillary Radiometric Product (MIANCARP)

This product comprises four files containing instrument characterization data, preflight calibration data, in-flight calibration data, and configuration parameters. MISR has challenging radiometric specifications of 3% absolute and 1% band and camera-relative calibration. The radiometric calibration is facilitated by use of an on-orbit calibrator (OBC) experiment, which is utilized at bi-monthly intervals. During these experiments a diffuse panel reflects solar light into the cameras. The intensity of this light is measured with on-board photodiode "detector standards." With the measured incident radiance and output DN, radiometric calibration coefficients are computed. Following each experiment the coefficients are packaged into a file called the Ancillary Radiometric Product (ARP). This new ARP file is used for the next two months to produce the MISR Level 1B1 radiance product, and in turn the Level 1B2 geolocated product.

The ARP contains coefficients and data variables which are used in the Level 1B1 processing. Updated ARP parameters include the sensor radiometric calibration coefficients, uncertainties in calibration, signal-to-noise ratios, pixel data quality indicators, and quality assessment threshold parameters. Static ARP parameters include spectral response parameters, point-spread-functions (PSF), field-of-view, passband-weighted solar irradiance values, and PAR integration weights. The ARP is regenerated periodically at the MISR SCF to update the instrument performance report. The ARP is used as input to Level 1B1 as well as Level 2 processing.

Data Product (ESDT): MIANCARP
 Data Set Long Name: MISR Ancillary Radiometric Product
 Sample File Name: MISR_AM1_ARP_INFLTCAL_Tyyy_Fnn_nnnn.hdf

where
 MISR = Instrument Name
 AM1 = Satellite Name
 ARP = Ancillary Radiometric Product
 INFLTCAL = In-flight Calibration
 Tyyy = Time window
 Fnn = Format (software) version of the product
 nn = Product Version number



2.4.4 MISR Cloud Screening Surface Classification (MIANCSSC)

This dataset contains a mapping of latitude/longitude values (at 1/6 degree resolution) to surface type, which is used in the calculation of the Radiometric Camera-by-Camera Cloud Mask (RCCM - L1B2), and the Angular Signature Cloud Mask (ASCM - L2TC). Both of these cloud masks are calculated by comparing calculated "observable" values against pre-determined thresholds, which vary by solar zenith angle and one of 1580 surface types. This dataset is also used to classify the surface type for the albedo calculations, and maps the detailed 1580 surface types into "vegetated" and "non-vegetated" land. Each one of these surface types is also mapped back into its corresponding "Olson World Ecosystem Class" (Version 1.4D).

Data Product (ESDT): MIANCSSC
 Data Set Long Name: MISR Cloud Screening Surface Classification
 Sample File Name: MISR_AM1_CSSC_Fnn_nn.hdf
 where
 MISR = Instrument Name
 AM1 = Satellite Name
 CSSC = Cloud Screening Surface Classification
 Fnn = Format (software) version of the product
 nn = Product Version number

Data Format: HDF-EOS Grid

2.4.5 MISR Terrestrial Atmosphere and Surface Climatology (MIANTASC)

This dataset contains several climatological parameters (such as surface ocean wind speed, snow-ice mask, surface pressure and temperature and tropopause height), on a one-degree by one-degree latitude/longitude grid. The current version of the dataset is only available on a monthly basis, with each month having the exact same data for all years (originally based on 1992 data). Work is currently underway to improve this, so the snow-ice mask and ocean surface wind-speeds will be based on real data (NSIDC and QuikScat) that will vary year-by-year. All other parameters in the dataset will retain their original 1992 values. The snow-ice masks are used in both the L2TC and L2AS algorithms, and the oceanic wind speeds are used in L2AS.

Data Product (ESDT): MIANTASC
 Data Set Long Name: MISR Terrestrial Atmosphere and Surface Climatology
 Sample File Name: MISR_AM1_TASC_XXX_F01_01.hdf
 where
 MISR = Instrument Name
 AM1 = Satellite Name
 TASC = Terrestrial Atmosphere and Surface Climatology
 XXX = Month
 Fnn = Format (software) version of the product
 nn = Product Version number

Data Format: HDF-EOS Grid

2.4.6 MISR Camera Geometry Model (MISANCGM)

The CGM dataset is used to describe pointing geometry of the nine MISR cameras. It consists of a set of parameters used in a mathematical expression that gives the pointing direction of an arbitrary pixel in the spacecraft attitude frame of reference. These parameters represent the geometry of the camera system and account for distortions from an ideal optical system. The specific parameters provided in the ASCII files are:

- the coefficients of a fifth-order polynomial to account for the nonlinear distortions of the field angle in the cross-track direction.
- the effective focal length.
- the detector size in the along-track and across-track direction.
- the pixel number (i.e., boresight pixel) corresponding to the x axis ($y = 0$).
- the separation of the particular band from the intersection of the z axis with focal plane.
- the rotation matrix function of the angles between camera and detector coordinate systems.
- the rotation matrix function of the angles between the instrument and camera coordinate systems.



- the rotation matrix function of the angles between the spacecraft and instrument coordinate systems.

More information can be obtained from the following two references which can be found in [Section 10](#) of this Handbook: Jovanovic, V.M., et al, "MISR photogrammetric data reduction for geophysical retrievals," and Jovanovic, V., et al, "Multi-angle geometric processing for globally geo-located and co-registered MISR image data."

Data Product (ESDT):	MISANCGM
Data Set Long Name:	MISR Camera Geometry Model
Sample File Name:	MISR_AM1_CGM_Fnn_nnnn.ascii
	where
	MISR = Instrument Name
	AM1 = Satellite Name
	CGM = Camera Geometry Model
	Fnn = Format (software) version of the product
	nnnn = Product Version number
Data Format:	ASCII

2.5 Special Products

2.5.1 Clim-Likely

The "**Clim-Likely**" aerosol climatology data set was developed pre-launch as an initial step in identifying a range of components and mixtures for the MISR Standard Aerosol Retrieval Algorithm climatology, and as one standard against which to compare MISR aerosol air mass type retrieval results. Six component aerosols included in the model were medium and coarse mode mineral dust, sulfate, sea salt, black carbon, and carbonaceous aerosols. Five aerosol air mass "Mixing Groups" and thirteen sub-groups were identified from a cluster analysis of the entire set of data. Each Mixing Group contains the four most abundant component particles in the column for climatologically common aerosol air masses. Each sub-group identifies the dominant particles within the Mixing Group. The data are derived from 'typical-year' aerosol transport model results and are available for individual 1° x 1° boxes or as global monthly files. The ["Clim-Likely" aerosol climatology data set](#) is available from the ASDC web site.

2.5.2 EOS Land Validation Project

In conjunction with the Earth Observing System (**EOS**) **Land Validation Project** easy access is provided to subsetting MISR data files over 26 core validation sites. These subsetting MISR data products are available in HDF-EOS format and are available from the [MISR Order Tool](#).

2.5.3 CERES-MISR Radiances

The CERES-MISR_MODIS SSF-SSF data set integrates measurements from the Clouds and the Earth's Radiant Energy System (CERES), MISR, and the Moderate Resolution Imaging Spectroradiometer (MODIS). The MISR Level 1B2 Ellipsoid and Terrain radiances from Collections 5 and 6 are identified with CERES Terra measurements reported in the Single Scanner Footprint (SSF) Edition2B product for days the CERES instruments (FM1 and FM2) are in along-track scanning mode. The scan and packet numbers unique to the CERES footprint provide the means to match the CERES and MISR data. The resulting data granule contains 2 files: an hour of instantaneous CERES SSF data which includes MODIS data and the matching CERES-MISR Single Scanner Footprint (SSF) daytime measurements (solar zenith angle < 90 deg). The ["CERES-MISR" radiance data](#) are available from the ASDC web site.

2.6 Field Campaigns

The following subsections give a brief overview for some of the MISR field campaigns. For all of the field campaigns, check the [campaign support page](#).

2.6.1 Central Mediterranean Aerosol and Radiation Experiment (C-MARE)

The Central Mediterranean Aerosol and Radiation Experiment (**C-MARE**) is a campaign that took place between September 20 and October 5, 2004 at the island of Lampedusa, Italy. The C-MARE region as defined by MISR covers paths 189 and 190, block 62. [C-MARE](#).



2.6.2 The International Consortium for Atmospheric Research on Transport and Transformation (ICARTT)

The International Consortium for Atmospheric Research on Transport and Transformation (**ICARTT**) was formed to take advantage of the synergy between several coordinated experiments to study the emissions of aerosols and ozone precursors, their chemical transformations and removal during transport to and over the North Atlantic. The capabilities represented by the consortium will allow an unprecedented characterization of the key atmospheric processes. The combined research conducted in the programs that make up ICARTT will focus in three main areas: regional air quality, intercontinental transport, and radiation balance in the atmosphere. [ICARTT](#).

2.6.3 Rain In Cumulus over the Ocean (RICO)

The Rain In Cumulus over the Ocean (**RICO**) field campaign from November 1, 2004 - February 1, 2005 targeted Antigua and Barbuda. The scientific issues included precipitation in trade wind cumulus, microphysics of the transition to a mature rainshaft, organization of trade wind clouds, water budget of trade wind cumulus, and the wind cloud environment. Over 50 scientists and organizations participated in the field campaign. MISR's mission objectives involved providing accurate information on cloud cover, cloud-track winds, stereo-derived cloud-top altitude, and cloud geometric thickness. The MISR data products supporting the entire RICO region correspond to MISR Paths 1, 2, 3, and 233, Blocks 74 - 78. [RICO](#).

2.6.4 United Arab Emirates-Unified Aerosol Experiment (UAE²)

The United Arab Emirates-Unified Aerosol Experiment (**UAE²**) 2004 field campaign during August 1 - October 31, 2004 targeted the coastal and desert regions of the United Arab Emirates. One major scientific goal was to evaluate and improve satellite derived aerosol and ocean products commonly used by the scientific community. Over 20 research laboratories participated in the field campaign. The MISR team defined the UAE region by the lat/lon coordinates 27N, 50E to 21N, 57E which corresponds to MISR Paths 155 - 166 and Blocks 68 - 74. MISR's mission objectives involved satellite calibration and validation of new MISR aerosol and aerosol height algorithms over dark water under mixed aerosol conditions and over bright surfaces with significant dust. [UAE²](#).

2.6.5 Gulf of Mexico Atmospheric Composition and Climate Study (GoMACCS)

Gulf of Mexico Atmospheric Composition and Climate Study (GoMACCS) was an intensive field study focused on providing a better understanding of the sources and atmospheric processes responsible for the formation and distribution of ozone and aerosols in the atmosphere and the influence that these species have on the radiative forcing of climate regionally and globally, as well as their impact on human health and regional haze. The study area encompassed Texas and the northwestern Gulf of Mexico from July - September 2006. [GoMACCS](#).

2.6.6 Intercontinental Chemical Transport Experiment phase B (INTEX-B)

The Intercontinental Chemical Transport Experiment phase B aims to understand the transport and transformation of gases and aerosols on transcontinental/intercontinental scales and assess their impact on air quality and climate. Phase B was performed March 1-31, 2006, and focused on Mexico City pollution outflow. [INTEX-B](#).

2.6.7 Saharan Mineral Dust Experiment (SAMUM)

The Saharan Mineral Dust Experiment (SAMUM) was dedicated to the understanding of the microphysical and optical properties of desert dust and the impact of desert dust on the global climate system. This experiment took place in southern Morocco during May and June 2006. [SAMUM](#).

2.6.8 Virtual Biomass Burning Experiment (VBBE)

The Virtual Biomass Burning Experiment (VBBE) was an aerosol experiment which took place in south east Asia during August and September 2007. [VBBE](#).



2.7 Further attributes of MISR products:

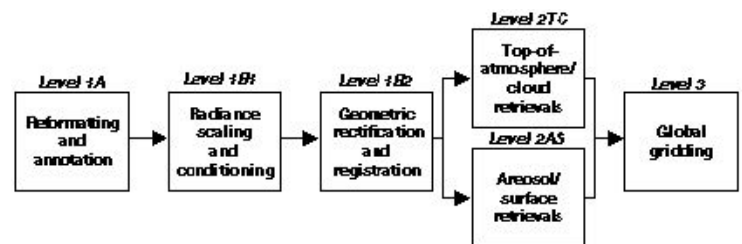
Product granularity

MISR products are generated with the following granularity:

- **Swath-based products:** All of the Level 1 and Level 2 Global Mode (GM) MISR products, which comprise the bulk of the science products, are generated on a swath basis. That is, each granule covers the daylit side of the Earth for a single orbit. HDF-EOS swath format is used by Level-1A (MI1A) and Level-1B1 (MI1B1) products only. Stacked-block HDF-EOS grid format is the native format used for the geolocated MISR Level-1 and Level-2 products. Conventional HDF-EOS grid format is designed to be an easier-to-use alternative to stacked-block grid format. Detailed information is provided in the [MISR Subsetted/Reformatted Products Quality Statement](#).
- **Scene-based products:** All of the Local Mode (LM) MISR products are on a single scene basis, where one LM scene is a 300-km along-track science data set with all cameras set to the highest resolution.
- **Orbit-based products:** MISR engineering data are transmitted from the instrument continuously, and are processed in whole-orbit granules to form the Level 1A engineering data product. The boundary between adjacent orbits is the dark-side equator crossing.
- **Event-based products:** The Level 1A products associated with calibration sequences, and with opening and closing of the instrument shutter mechanism, are each processed on a single-event basis.
- **Global Gridded products:** The MISR Level 3 Products are global maps of select parameters from the Level 2 products reported on a 0.5° x 0.5°, a 1° x 1°, 2.5° x 2.5°, or a 5° x 5° geographic grid depending on the data product. Associated covariances are reported on a 1° x 1° grid.

3. Data Processing

The generation of MISR science data products at ASDC can be divided into five production steps. Each step has at least one primary output product, but may have other secondary output products. It is convenient to think of these five steps as occurring in sequence, with the predecessor producing at least one complete product, a portion of which is the primary input for the successor.



Each of these steps corresponds to processing levels of a product generation flow, as shown in the above diagram. These levels conform to the EOS scheme from Level 1 to Level 3, where each successive level has a higher degree of processing.

- Level 1 processing provides corrected (or calibrated) instrument data. These measurements are processed and calibrated to remove many of the instrument effects. The resulting products thus contain minimal instrument or spacecraft artifacts and are most suitable for subsequent scientific investigations.
- Level 2 processing provides retrieval of derived scientific quantities, such as atmospheric aerosol, cloud, and surface measurements.
- Level 3 processing produces global gridded maps of various parameters from the Level 2 products. These global maps are produced daily, monthly, quarterly, and yearly at grid resolutions of 0.5° x 0.5° to 1.0° x 1.0°.

Production of standard products at ASDC includes a dependency on the MISR Science Computing Facility (SCF) for certain functions. For example, there is critical dependence on calibration parameters and lookup data, such as threshold data sets, climatologies, model data sets or the like. These functions are separated from ASDC activities because they require close day-by-day scrutiny by the MISR science team. Updates to these data structures occur infrequently compared to the rate of standard product generation, and therefore fit into the more limited processing capabilities of the SCF. Other essential functions that have activity at the SCF include quality assessment, algorithm validation, software development, and instrument operations.

MISR uses a Format Version to distinguish between software deliveries to ASDC that result in a product format change. A format version number is given in the MISR data file name using the designator `_Fnn_` where nn is the version number. MISR also gives each file a Product Version designation to indicate changes in the science content of the product. Early on in the mission, several significant changes to ancillary datasets were required, and these changes triggered Product Version increments. Most of the static ancillary datasets have stabilized and major changes to them are not expected. Therefore, Product Version numbers are not necessarily incremented because of ancillary dataset deliveries. A product version number is given in the MISR data file name using the designator `_nnnn_` where nnnn is the product version number. As MISR continues to reprocess the data products, ["Collections"](#) of scientifically consistent sets of data Product and Format versions are becoming available. [MISR Processing information](#) is available and can also be found on the [MISR Data Table](#).



4. Validation

Science validation consists of comparisons of MISR data with similar measurements from ground aircraft or space-based observations, together with conventional methods of analysis and inversion. These intercomparisons also serve in some instances to validate the assumed aerosol climatology and surface reflectance models used in the retrievals. Detailed validation information is provided on the MISR [Validation web site](#).

AirMISR Instrument Onboard NASA's ER-2



5. Data Quality

Each MISR data product goes through several levels of product maturity: Beta, Provisional, and Validated Stages 1 through 3. MISR products are first released publicly at the Beta level, and then progress through the Provisional to the Validated levels--from a developmental status to a scientifically proven status. Intensive assessment of MISR product data quality never stops although focused studies of some parameters are now complete. Uncertainties for specific parameters are reported in individual [Data Product Quality Statements](#). These Quality Statements are also linked to [Versioning History Documents](#). Below are the Maturity Level definitions:

Beta:	Early release products for users to gain familiarity with data formats and parameters.
Provisional:	Limited comparisons with independent sources are complete and obvious artifacts corrected.
Validated Stage 1:	Uncertainties are estimated from independent measurements at selected locations and times.
Validated Stage 2:	Uncertainties are estimated from more widely distributed independent measurements.
Validated Stage 3:	Uncertainties are estimated from independent measurements representing global conditions.

6. MISR Imagery

The NASA Langley ASDC web site provides an [ASDC Image Gallery](#) of featured MISR images that may be accessed via a thumbnail list, an indexed list, or a map. Also displayed at the ASDC web site are illustrations of the MISR instrument viewing the Earth and a MISR Browse Atlas that displays a time series of browse images for the continental United States and for specified field experiments. The Level 3 imagery, discussed in Section 2.3, are also available at the ASDC Image Gallery.

The ASDC web site includes a [MISR Browse Tool](#) to allow easy access to images from the MISR instrument. The browse images are true color images created from the L1B2 ellipsoid radiance data for each camera reduced to 2.2km resolution. The MISR red, green and blue bands are used to create the color image, which are intentionally clipped and gamma-stretched to make cloud, ocean and land features visible. Note that the northernmost and southernmost 25 blocks of each path are not shown on the data selection path maps as there is considerable overlapping of paths in the polar regions. The browse images are JPEG format. The Tool provides information to help determine MISR paths, orbits and block numbers for specific geographic regions, and cloud free data prior to ordering.

The MISR web site at JPL also provides an [Image Gallery](#) of featured images by geographic area, image type, or date of release. A full image library, including the higher resolution formats generally preferred for publication, is found on NASA's [Planetary Photojournal](#).

7. Data Access:

Publicly distributed MISR data are accessible through the ASDC MISR Order and Customization Tool, through the ASDC Data Pool, and the Reverb Search Tool. MISR information at the [ASDC web site](#) includes Documentation, Data Versioning and Processing Status, Data Availability, and Tools for working with the data. This site also includes Search and Order Tips, an FAQ, a Powerpoint presentation called *"How-to" obtain MISR information and data*, and links to the ordering tools. In addition, the page has an Orbit-to-Date and Lat/Lon-to-Path/Block conversion tools to help with particular MISR geographic locations and data availability.

The MISR data product files can be quite large -- for example, a Level 1B2 ellipsoid data product file is approximately 600 Megabytes each.



Table B lists the nominal file sizes of available data sets.

Table B. ESDT Shortnames and Nominal File Sizes of Available MISR Data Sets

ESDT Shortname	Frequency	Nominal File Sizes (Mb)	ESDT Shortname	Frequency	Nominal File Sizes (Mb)
MIL3DRD	Daily	91	MI1B2E	(15x9)/Day	200 (Oblique), 600 (Nadir)
MIL3MRD	Monthly	470	MI1B2T	(15x9)/Day	100 (Oblique), 350 (Nadir)
MIL3QRD	Quarterly	524	MIB2GEOP	15/Day	6
MIL3YRD	Yearly	560	MIRCCM	(15x9)/Day	10
MIL3DLS	Daily	1	MB2LME	9 per acquisition	12
MIL3MLS	Monthly	3	MB2LMT	9 per acquisition	12
MIL3QLS	Quarterly	4	MISBR	(15x9)/Day	1
MIL3YLS	Yearly	6	MIL1A	(15x9)/Day	400 (Oblique), 900 (Nadir)
MIL3DAE	Daily	1	MI1B1	(15x9)/Day	400 (Oblique), 1300 (Nadir)
MIL3MAE	Monthly	2	MIB1LM	9 per acquisition	30
MIL3QAE	Quarterly	3	MI1AENG1		2
MIL3YAE	Yearly	4	MI1ANAV		1
MIL3DAL	Daily	4	MI1AMOT		1
MIL3MAL	Monthly	16	MI1AC		75
MIL3QAL	Quarterly	22	MI1AOBC		1
MIL3YAL	Yearly	14	MIANACP	n/a	1
MIL2ASAE	15/Day	40	MIANCAGP	1 per path	110
MIL2ASLS	15/Day	600	MIANCARP	n/a	5
MIL2TCST	15/Day	100	MIANCSSC	n/a	5
MIL2TCAL	15/Day	375	MIANTASC	n/a	13
MIL2TCCL	15/Day	4	MISANCGM	n/a	1

7.1 MISR Order and Customization Tool

A [MISR Order and Customization Tool](#) is available that enables users to order and customize data in a single interface. Some features are non-consecutive path and orbit search; and sorting search results by date, camera, path, orbit, and file version. Customization options are subsetting by parameter, block, and spatial coordinates; additional latitude and longitude layers, and unpacking and unscaling applicable fields; and outputting data in HDF-EOS stacked-block grid or conventional grid. The reformatting option, referred to as "Conventional HDF-EOS", is designed to be an easier-to-use alternative to MISR's stacked-block format. Please read the [MISR Subsetting / Reformatted Products Quality Statement](#) prior to using the interface. The interface currently supports two output formats:

1. Stacked-block HDF-EOS (original file format)
2. Conventional HDF-EOS grid

Stacked-block Background



Stacked-block vs Aligned File



Conventional Grid Product



7.2 ASDC Data Pool



Distributed by the Atmospheric Science Data Center
<http://eosweb.larc.nasa.gov>



MISR data are also available through the [ASDC Data Pool](#) (an on-line, short-term data cache that provides a Web interface and FTP access). Specially subsetted and/or reformatted MISR data products supporting field campaigns are also available. Passive FTP mode is required to access the Data Pool from the command line as "ftp -p l4ftl01.larc.nasa.gov". The beginning of the ftp server name "l4ftl01.larc.nasa.gov", which spelled out in English is "lower case L four ft lower case L zero one". A UNIX C shell script may be used to assist in downloading files from the Data Pool. Data files are stored in directories based on data product and acquisition date. Corresponding metadata files are available in Extensible Markup Language (XML) format.

7.3 Reverb Search Tool

The [Reverb Search Tool](#) is a search and order service for Earth science data and provides access to distributed MISR data. It allows users to search science data holdings and place orders for data products.

7.4 Distribution Methods:

MISR Data Products are in HDF-EOS format and are available via FTP Pull and FTP Push, DVD, DLT, CD, and 8mm tape from ASDC.

8. Working with the Data

8.1 Tools Available

Several software tools for reading, visualizing and working with MISR data are available through the NASA Langley ASDC. Below is a brief description which includes links for each tool.

8.1.1 Browse Tool

The [MISR Browse Tool](#) allows easy access to images from the MISR instrument. The browse images are ellipsoid-projected color images for each camera reduced to 2.2km resolution. The MISR red, green and blue bands are used to create the color image, which are intentionally clipped and gamma-stretched to make cloud, ocean and land features visible. Note that the northernmost and southernmost 25 blocks of each path are not shown on the data selection path maps as there is considerable overlapping of paths in the polar regions. The browse images are JPEG format. The Tool provides information to help determine MISR paths, orbits and block numbers for specific geographic regions, and cloud free data prior to ordering.

8.1.2 Orbit/Date Conversion

This interactive interface converts dates to MISR Orbit number and MISR Orbit numbers to dates. [Orbit/Date Conversion](#).

8.1.3 Lat/Lon to Path/Block Conversion Tools

The [Lat/Lon to Path/Block Conversion Tool](#) is an interactive interface for obtaining MISR paths based on latitude and longitude.

8.1.4 ENVI

The misr_envi tool imports MISR Level 1B2 Ellipsoid and Terrain stacked-block data into ENVI. The data are automatically geolocated and the band information is correctly interpreted, improving the way ENVI understands such files and presents their contents. An extension to the tool reads and geolocates the Land BRF parameter from MISR Level 2 Land Surface data files.

The tool consists of a set of routines written in Exelis Visual Information Solutions Interactive Data Language (IDL) programming language which implements an ENVI User Function for working with MISR L1B2 data. MISR map projection definitions are provided for augmenting the ENVI defined map projections file, and a sample ENVI menu file which adds a menu item to invoke this tool is also included. The tool runs in



ENVI version 4.0 and higher. [ENVI download information](#).

8.1.5 misr_view

This software tool for visualization of MISR and AirMISR data files was developed by NASA's Jet Propulsion Laboratory. `misr_view`, which includes a User's Guide, is available for download free of charge from the [Open Channel Foundation](#). Foreign Friends of MISR should obtain the tool from the MISR website: read the introductory information and select item 8 in the table of software packages to obtain the license agreement from the [MISR Science Software web page](#).

`misr_view` is a graphical user interface display and analysis tool for use with many types of MISR and AirMISR data. It is written in IDL and it is specifically designed for use with those MISR and AirMISR files that use the HDF-EOS stacked-block "grid" interface. These data include MISR L1B2 georectified (map-projected) radiance, MISR L1B2 radiometric cloud mask, all MISR Level 2 geophysical products, the MISR Ancillary Geographic Product, and AirMISR L1B2 georectified radiances. For MISR data, the user interface provides data selection for specified orbits, paths, or observation dates, and enables translation between these modes of identification. The interface to AirMISR data is simplified. The display and analysis tools include simultaneous display of several data planes through color assignment, contrast enhancement, data value query, image rotation, creation of stereo anaglyphs, zooming, and linked analysis and view windows.

`misr_view` can be run either with a licensed version of the IDL package or by using the IDL Virtual Machine (VM) application. The IDL VM comes bundled with IDL and is available from [Exelis Visual Information Solutions](#) (Exelis VIS). `misr_view` 5.0 requires version 6.1 of IDL or the IDL VM.

`misr_view` was developed by the Visualization and Earth Science Applications Group of the Image Processing Applications and Development Section at the Jet Propulsion Laboratory.

8.1.6 misr_time

The `misr_time` tool calculates the block center times for MISR Level 1B2 files. This tool is particularly useful for files processed before August 2003. Data processed after that time includes these center block times stored in the file in the `PerBlockMetadataTime` vdata structure.

This tool creates an output file containing the block number and the block center time for each good data block within a MISR L1B2 file.

The `misr_time` tool is written in Exelis Visual Information Solutions IDL programming language. It can be run either with a licensed version of the IDL package or by using the IDL VM application. The IDL VM comes bundled with IDL and is available from [Exelis Visual Information Solutions](#). The IDL VM software may be downloaded from this site or ordered from Exelis VIS on CD at no cost. The site provides installation instructions. The `misr_time` tool was developed and tested with IDL and IDL VM version 6.1.

Additional information, including installation and program execution instructions, is available in a [Readme file](#).

The `misr_time` tool software can be downloaded as a tar file containing nine files, [misr_time.tar](#). The files may be extracted from the tar package using the Unix tar command or a utility such as WinZip on Windows PCs.

8.1.7 IDL Utilities

The MISR IDL Utilities are a set of callable routines written in Exelis Visual Information Solutions IDL language that can be used to read data and metadata values stored in MISR Level 1B2, Level 2 and Level 3 data products. A set of wrapper routines is also provided to show the use of these routines with MISR data products. Additional information is available in a [README document](#).

A tar file package is available for download which can be opened on Unix systems with the tar utility or on Windows systems with a utility such as WinZip, or the files may be downloaded individually.

8.1.8 Conversion to ASCII

The MISR ASCII conversion routines read parameters from MISR Level 1B2 or AGP data files and write those parameters to a set of ASCII formatted files, with one output file for each MISR block for each parameter.

These routines are written in Exelis Visual Information Solutions IDL programming language. They can be run either with a licensed version of the IDL software package or by using the IDL Virtual Machine application. Additional information, including installation and program execution instructions, is available in a [Readme file](#).



The ASCII conversion software can be downloaded as a tar file containing nine files, [misr_ascii.tar](#). The files may be extracted from the tar package using the Unix tar command or a utility such as WinZip on Windows PCs.

8.1.9 hdfscan

This software tool for visualization of MISR and AirMISR data files is distributed by NASA's Jet Propulsion Laboratory. hdfscan, which includes a User's Guide, is available for download free of charge from JPL upon completion of a license agreement.

hdfscan software consists of two components - a core HDF file reading engine and a graphical user interface (GUI) built as a wrapper around the core engine. The core engine can be executed as a standalone command-line application. The core engine is written in Fortran90. The GUI is written in a combination of Tcl/tk, C, and C++. These were designed and tested to run on Sun Solaris 7 and higher and SGI IRIX 6.5 environments.

hdfscan was developed at the Jet Propulsion Laboratory. To obtain the license agreement, go to the [MISR Science Software web page](#), read the introductory information, and select item 8 in the table of software packages.

8.1.10 MISR HDF-to-Binary Converter and Radiance/BRF Calculation Tools

Two tools, HDFDUMP and BRFDUMP, were developed for use with MISR gridded data files. HDFDUMP will extract data from a MISR file in the HDF-EOS grid format (MISR Level 1B2 and Level 2 files) and writes unformatted binary files. BRFDUMP calculates radiances and bidirectional reflectance factors (BRF) from MISR Level 1B2 files and creates unformatted binary files.

These programs are written in Fortran 90 and have been tested on a Silicon Graphics, Inc. (SGI) Origin 2000 running IRIX 6.5 with the MIPSpro 7 Fortran 90 compiler. The pre-compiled executables supplied in the package were built in -n32 -mips4 mode on an SGI, suitable for the R8000, R10000 and R12000 cpus normally found in Challenges and Origins.

In order to build these programs it is necessary to have the HDF and HDF-EOS libraries for the target computer. The HDF libraries are available from the The HDF Group (THG) at: <http://www.hdfgroup.org>.

and the HDF-EOS libraries are available from the EOS project at: <http://hdfeos.org/>.

HDF and HDF-EOS are also bundled with the SDP Toolkit distribution which is available from the [SDP Toolkit Home Page](#).

Two unix script files are included which will compile these programs, *bld.hdfdump* and *bld.brfdump*. These scripts will need to be modified to reference the installed locations of the HDF include and library files and the HDF-EOS include and library files on the target computer.

8.1.11 HDF-EOS to GIS Format Conversion Tool

The HDF-EOS to Geographic Information Systems (GIS) Format Conversion Tool (HEG) was developed by the Earth Observing System (EOS) Core System (ECS) Project Office to allow a user to reformat, re-project and perform stitching/mosaicing and subsetting operations on HDF-EOS objects. The output GeoTIFF file is ingestible into commonly used GIS applications. HEG will also write to native (or raw) binary and HDF-EOS Grid formats. HEG presently works with MODIS (Aqua and Terra), ASTER, and MISR HDF-EOS data sets.

The tool is accessible via a command line interface or by a GUI. The tool operates on Sun, SGI, Linux, Windows, and Macintosh OS X platforms. Java 1.3 or higher is required to run HEG.

MISR Products Tested:

- Level 1B2 Ellipsoid Product (MI1B2E)
- Level 1B2 Terrain Product (MI1B2T)
- Level 2 Land Product (MIL2ASLS)
- Level 2 Aerosol Product (MIL2ASAE)
- Level 2 Cloud Product (MIL2TCST)

The HEG tool may be obtained from the Tools section of the [HDF-EOS Tools and Information Center](#) or via ftp. Sample ftp download session follows below. User input is indicated in **bold**:

```
ftp edhs1.gsfc.nasa.gov
UserName: anonymous
Password: your e-mail address
ftp> quote site group sdptk
```



```

200 Request for access to group sdptk accepted.
ftp> quote site gpass ecs-tkit
200 Group access enabled.
ftp> cd HEG_Tool
250 CWD command successful.
ftp> bin
ftp> get <the heg* for your system, Users Guide, and Readme file>
ftp> bye

```

Installation instructions are included in the software delivery package or the README file, depending on your platform.

8.1.12 Data Manipulation Software

Public Domain and Commercial Software packages are listed at the [ASDC web site](#).

8.2 Geolocating MISR Data

This process is described in the MISR Data Products Specifications, [Appendix A](#). There are two methods for doing this:

1. Look up the Lat/Lon of the corresponding block, line, sample in the Ancillary Geographic Product (AGP) data sets.

MISR geolocation information is located in the MISR Ancillary Geographic Product (AGP) files. The fields "GeoLatitude" and "GeoLongitude" contain the desired information. These values are stored on the "Standard" (1.1 km) grid of the AGP; you may need to interpolate or extrapolate if the parameter you are working with is on a different grid. Latitudes are geodetic, and longitudes are relative to the Greenwich meridian, positive to the east and negative to the west.

Users need to obtain the AGP file that corresponds to the path of the data you are trying to geolocate. The path is given in the MISR data file name using the format _Pxxx_ where xxx is the path number (1-233). The AGP files are permanently available from the [Data Pool](#).

2. Mathematically convert the SOM block, line, and sample (pixel) to latitude and longitude. This is a two-step process. Algorithms are provided in the DPS [Appendix A](#).
 - Convert(block, line, sample) \Leftrightarrow SOM(x,y)
 - Requires several metadata values from the data file and some arithmetic
 - Convert SOM(x,y) \Leftrightarrow Lat/Lon
 - Requires use of GCTP (General Coordinate Transformation Package) map projection coordinate conversion library in HDF-EOS distribution or some other software that incorporates GCTP, such as IDL.

8.3 Converting Numbers Stored in Files to Physical Quantities

At Level 1A, the 14 most significant bits (MSB) directly represent the raw digital count from the camera's Charge-Coupled Device (CCD). The 2 least significant bits (LSB) of the 16-bit data values are data quality indicators (DQI). A DQI of 0 means the data meet all specifications; 1 means some degradation in quality has occurred but the data are still valid; 2 means the data should not be used for scientific analysis; and 3 means the data are not usable. At Level 1B1, the image data and the data quality indicators are stored as separate fields. The image data values represent "scaled radiances", which means that they must be multiplied by a scale factor to obtain radiance in units of Watts/square meters/steradian/micrometer. These band-by-band scale factors are stored in the **swath** metadata of L1B1 files, and are found within the attributes of the swath structures. The data quality indicators follow the same convention described above.

For Level 1B2 data, the image data and the data quality indicators are once again packed into 16-bit words. The 14 MSB's represent "scaled radiances", and the 2 LSB's are DQI values that follow the same convention described above. The conversion from scaled radiance to radiance (Watts/square meters/steradian/micrometer) requires multiplication by a scale factor. These band-by-band scale factors are stored in the **grid** metadata of L1B2 files, and are found within the attributes of the grid structures. Note that certain high values of the scaled radiances at L1B1 and L1B2 are reserved for fill, as described in the [Data Products Specification Document](#).

8.4 Converting Data in L1B2 Products to TOA BRF

Since November 2002 (product version 0016 and later), the MISR L1B2 products contain parameters within the file that make it easier to



convert radiances to BRF. The BRF conversion factor for each band is derived from the equation:

$$(\pi * \text{SunDistanceAU}^2) / (\text{std_solar_wgted_height} * \cos(\text{SolarZenith}))$$

This factor can be used to calculate the BRF:

$$\text{BRF} = \text{BRF conversion factor} * \text{Radiance}$$

The Radiance may be obtained from the Radiance/RDQI by right-shifting 2 bits, then multiplying the result by the Scale factor (radiometric) contained in the Radiance Grid Metadata.

9. Associated Costs:

Currently, there is no cost associated with MISR data. However, for large media orders the NASA Langley ASDC may require a one-to-one media exchange. The User Services office will contact users who have made a large order to request confirmation if a media exchange is necessary.

10. References:

Here are several references to papers that give an instrument overview and an introduction to the aerosol and surface retrievals.

Diner, D.J., J.C. Beckert, T.H. Reilly, C.J. Bruegge, J.E. Conel, R. Kahn, J.V. Martonchik, T.P. Ackerman, R. Davies, S.A.W. Gerstl, H.R. Gordon, J-P. Muller, R.B. Myneni, R.J. Sellers, B. Pinty, and M.M. Verstraete (1988). "Multi-angle Imaging SpectroRadiometer (MISR) description and experiment overview." *IEEE Trans. Geosci. Rem. Sens.*, **36**, pp 1072-1087.

Martonchik, J.V., D.J. Diner, R. Kahn, T.P. Ackerman, M.M. Verstraete, B. Pinty, and H.R. Gordon (1988). "Techniques for the retrieval of aerosol properties over land and ocean using multi-angle imaging," *IEEE Trans. Geosci. Rem. Sens.*, **36**, pp 1212-1227.

Martonchik, J.V., D.J. Diner, B. Pinty, M.M. Verstraete, R.B. Myneni, Yu. Knyazikhin, and H.R. Gordon (1988). "Determination of land and ocean reflectance, radiative, and biophysical properties using multi-angle imaging," *IEEE Trans. Teosci. Rem. Sens.*, **36**, pp 1266-1281.

Jovanovic, V.M., Smyth, M.M., Zong, J., Ando, R., Bothwell, G.W. (1998), "MISR photogrammetric data reduction for geophysical retrievals," *IEEE Trans. Goesci. Rem. Sens.*, **36**, No. 4.

Jovanovic, V., Moroney, C., & Nelson, D. (2006). "Multi-angle geometric processing for globally geo-located and co-registered MISR image data," *Remote Sensing of Environment*, accepted for publication.

A complete list of MISR peer-reviewed publications can be found on the [MISR Publications page](#). In many instances there are links to abstracts and full texts of papers.

11. Glossary and Acronyms:

[EOSDIS Acronyms](#) (PDF).

12. List of Acronyms:

ACP - Ancillary Climatology Product
AGP - Ancillary Geometric Product
APOP - Aerosol Physical and Optical Pillary Radiometric Product
ASAE - Aerosol parameters
ASCM - Angular Signature Cloud Mask
ASDC - Atmospheric Science Data Center
ASLS - Aerosol Land Surface
ASOS - Aerosol Ocean Surface
ASTER - Advanced Spaceborne Thermal Emission and Reflection Radiometer
ATBD - Algorithm Theoretical Basis Documents
BR - Browse
BRF - Bidirectional Reflectance Factor
CCD - Charge-Coupled Device
CERES - Clouds and the Earth's Radiance Energy System

CGAL - Component Global Albedo Product
CGAS - Component Global Aerosol Product
CGLS - Component Global Land Surface Product
CGGRP - Component Global Georectified Radiance Product
CGM - Camera Geometry Model
CM - Calibration Mode
C-MARE - Central Mediterranean Aerosol and Radiation Experiment
CSSC - Cloud Screening Surface Classification
DAAC - Distributed Active Archive Center
DEM - Digital Elevation Model
DHR - Directional Hemispherical Reflectance
DN - Data Number
ECS - EOSDIS Core System
EOS - Earth Observing System
EDOS - Earth Observing System Data and Operations System
EOSDIS - Earth Observing System Data Information System
ESDT - Earth Science Data Type
ESE - Earth Science Enterprise
Exelis VIS - Exelis Visual Information Solutions (was ITT VIS)
FPAR - Fraction of Photosynthetically Active Radiation
FTP - File Transfer Protocol
GCMD - Global Change Master Directory
GEOP - Geometric Parameters
GIS - Geographic Information Systems
GM - Global Mode
GOMACCS - Gulf of Mexico Atmospheric Composition and Climate Study
GRP - Georectified Radiance Product
GUI - Graphical User Interface
HDF - Hierarchical Data Format
HDF-EOS - Hierarchical Data Format - Earth Observing System
HEG - HDF-EOS to Geographic Information Systems Format Conversion Tool
ICARTT - International Consortium for Atmospheric Research on Transport and Transformation
IDL - Interactive Data Language
IFOV - Instantaneous Field-of-View
INFLTCAL - In-flight Calibration
INTEX-B - Intercontinental Chemical Transport Experiment phase B
JPL - Jet Propulsion Laboratory
km - kilometers
LAI - Leaf Area Index
LaRC - Langley Research Center
LM - Local Mode
m - meter
MISR - Multi-angle Imaging SpectroRadiometer
MODIS - Moderate Resolution Imaging Spectroradiometer
MSB - Most Significant Bits
nm - nanometer
NASA - National Aeronautics and Space Administration
NCSA - National Center for Supercomputing Applications
NDVI - Normalized Difference Vegetation Index
NIR - Near-InfraRed
OBC - On-Board Calibrator
PAR - Photosynthetically Active spectral Region
PGE - Product Generation Executable
PP - Projection Parameters
PSF - Point Spread Function
RCCM - Radiometric Camera-by-camera Cloud Mask
RH - Relative Humidity
RICO - Rain In Cumulus over the Ocean
RLRA - Reflecting Level Reference Altitude
ROI - Reference Orbit Image
RP - Radiance Product
RSI - Research Systems, Inc. (now Exelis Visual Information Solutions)
SAMUM - Saharan Mineral Dust Experiment
SCF - Science Computing Facility
SDCM - Stereoscopically Derived Cloud Mask
SGI - Silicon Graphics, Inc.
SOM - Space-Oblique Mercator
SWAMP - Science Working Group for the AM Platform
TASC - Terrestrial Atmosphere and Surface Climatology
TC - Top-of-Atmosphere/Cloud Product



TCAL - Top-of-Atmosphere/Cloud Albedo
TCCL - Top-of-Atmosphere Cloud Classifiers
TCST - Top-of-Atmosphere/Cloud Stereo
TOA - Top of Atmosphere
UAE² - United Arab Emirates-Unified Aerosol Experiment
VM - Virtual Machine
WGS - World Geodetic System 1984
WRS - Worldwide Reference System
XML - Extensible Markup Language

13. Acknowledging Use of MISR Data and Images

The requested form of acknowledgment for any publication in which MISR data are used is: "*The MISR data were obtained from the NASA Langley Research Center Atmospheric Science Data Center.*"

The Langley Data Center requests a reprint of any published papers or reports or a brief description of other uses (e.g., posters, oral presentations, etc.) of data that we have distributed. This will help us determine the use of data that we distribute, which is helpful in optimizing product development. It also helps us to keep our product-related references current. To assist the Langley Data Center in providing the best service to the scientific community, we request notification if you transmit these data to other researchers.

The requested form of acknowledgment for using any MISR images available from the NASA Langley [ASDC Collections](#) or from the MISR JPL site is: "*Image credit: NASA/GSFC/LaRC/JPL, MISR Team*".

14. Contact Information:

If you have a problem finding information, data products or tools, trouble ordering data or accessing your order, or just have a question, please contact the User Services staff. Normal business hours are 8:00 AM to 4:30 PM Eastern Time, Monday through Friday.

User Services Office
Atmospheric Science Data Center
NASA Langley Research Center
Mail Stop 157D
Hampton, Virginia 23681-2199
USA.
Telephone: (757) 864-8656
E-mail: support-asdc@earthdata.nasa.gov

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